FIELD OF THE INVENTION

The present invention relates to a complete or partial shoulder or hip prosthesis making it possible to reproduce, with an improved degree of precision, the characteristics of a natural joint.

BACKGROUND OF THE INVENTION

In the domain of shoulder prostheses, it is known, for example from European Patent Application 0 299 889, to create a convex articular surface on a glenoid component, while a concave articular surface of corresponding shape is formed on a humeral component. The glenoid component of such a surface is very invasive and a subacromial conflict of the humeral component may occur at the end of a movement of abduction.

Furthermore, U.S. Patent No. 4 846 840 discloses producing, on an intermediate element of a prosthesis, two substantially concentric convex surfaces with a view to their articulation on concave surfaces of corresponding shapes, provided respectively on two bones to be articulated on each other. Such a prosthesis is unstable, particularly due to the offset between the two sets of articular surfaces provided in this prosthesis.

It is a more particular object of the invention to overcome these drawbacks by proposing a shoulder or hip joint prosthesis reproducing the anatomical articulation, while facilitating the abduction of the arm or the leg, in the absence of the cover of the rotators for the shoulder or of the stabilizing structures of the hip, thanks to an increase of the lever arm of the effort exerted by the deltoid muscle or the gluteus medius muscle at the beginning of abduction.

SUMMARY OF THE INVENTION

In this spirit, the invention relates to a shoulder or hip prosthesis which

comprises a humeral or femoral component presenting a concave articulation surface and an intermediate component presenting first and second convex articulation surfaces, intended to cooperate respectively with the concave articulation surface of the humeral or femoral component and with a concave glenoid or cotyloid articulation surface, natural or belonging to a glenoid or cotyloid component. This prosthesis is characterized in that the locus of the instantaneous centres of rotation of the first convex articulation surface with respect to the concave humeral or femoral articulation surface, and the locus of the instantaneous centres of rotation of the second convex articulation surface on the glenoid or cotyloid articulation surface, lie on either side of the first convex surface.

Thanks to the invention, in the case of a shoulder prosthesis, the lever arm of the deltoid muscle exerting the effort of abduction of the humerus on the shoulder is great, which facilitates the abduction thanks to a slide of the concave humeral articulation surface with respect to the first convex articulation surface of the intermediate element. In the case of a hip prosthesis, the abduction of the femur, which is controlled by the gluteus medius muscle, is facilitated.

According to advantageous aspects of the invention, this prosthesis incorporates one or more of the characteristics of Claims 2 to 12.

BRIEF DESCRIPTION OF THE DRAWINGS

The invention will be more readily understood and other advantages thereof will appear more clearly in the light of the following description of four forms of embodiment of a prosthesis in accordance with its principle, given solely by way of example and made with reference to the accompanying drawings, in which:

Figure 1 is a sagittal section of a shoulder prosthesis according to the invention in place on a patient, while the patient's arm is in lower position.

Figure 2 is a section similar to Figure 1 during a first phase of the movement of abduction of the humerus.

Figure 3 is a section similar to Figure 1 during a second phase of the movement of abduction.

Figure 4 is a section similar to Figure 1 at the end of the movement of abduction.

Figure 5 is a section similar to Figure 1 when the prosthesis is subjected to an effort tending to move it away from its position of equilibrium.

Figure 6 is a section similar to Figure 1, on a smaller scale and with the femur shown in outside view, for a hip prosthesis in accordance with a second form of embodiment of the invention.

Figure 7 is a longitudinal section of a shoulder prosthesis in accordance with a third form of embodiment of the invention.

Figure 8 is a section along line VIII-VIII of Figure 7, VII-VII indicating the plane of section of Figure 7.

Figure 9 is a view in perspective of a part of the humeral component of the prosthesis of Figures 7 and 8.

Figure 10 is a view similar to Figure 7 for a hip prosthesis in accordance with a fourth form of embodiment of the invention.

Figure 11 is a section along line XI-XI of Figure 10, X-X indicating the plane of section of Figure 10, and

Figure 12 is a view in perspective of a part of the femoral component of the prosthesis of Figure 10.

DESCRIPTION OF PREFERRED EMBODIMENTS

Referring now to the drawings, the prosthesis P shown in Figures 1 to 5 comprises a humeral component 1 which includes a part 11 intended to be anchored in the medullary cavity of the humerus H of the articulation to be equipped with the prosthesis P. Part 11 extends by a stem 12 projecting outside the humerus once the latter is resectioned and at the end of which is formed a plate 13 in one piece with parts 11 and 12. This plate might equally well be connected on parts 11 and 12.

The plate 13 defines a concave surface S_1 of which the concavity faces towards the glenoid cavity G of the shoulder.

The prosthesis also comprises a glenoid component 2 anchored in the glenoid cavity of the shoulder and defining a concave surface S_2 whose concavity faces towards the outside of the glenoid cavity.

Between the components 1 and 2 there is interposed an intermediate component 3 forming a hollow dish 31 inside which are immobilized a button 32 and a washer 33.

The elements 32 and 33 are fixed by any appropriate means inside the dish 31, for example by screwing, interlocking and/or adhesion. In a variant, the button 32 may be in one piece with the dish 31.

S'_1 denotes the convex surface of the button 32 accessible from outside the dish 31.

The surfaces S_1 and S'_1 are both portions of sphere having substantially the same radius R_1, with the result that the plate 13 can slide over the surface S'_1 of the button 32.

The convex outer surface S'_2 of the dish 31 is also in the form of portions of sphere, with a radius R_2 similar to the radius of the surface S_2, this allowing a relative sliding movement of the surfaces S_2 and S'_2.

The elements 32 and 33 are housed in an internal volume V of the dish 31, this volume being defined inside the surface S'_2 and an imaginary disc D in abutment on the peripheral edge 311 of the dish 31. According to a variant of the invention (not shown), the washer 33 may project out of the volume V.

The plate 13 is in the form of a dish and extends around the stem 12, forming a circular peripheral extension or projection 14 which may be engaged in a peripheral notch 34 made, in the volume V, between the button 32 and the washer 33.

The washer 33 comprises an internal truncated surface 331 against which the stem 12 may come into abutment, with the result that the surface 331 constitutes a stop for the movement of slide of the plate 13 with respect to the button 32. The surface 331 is not necessarily truncated.

Z-Z' denotes a vertical axis substantially parallel to the spine of the patient when standing.

The component 3 is subjected to the weight P_3, as well as to an effort F_1 which is transmitted thereto by the glenoid cavity. This assembly is also subjected to an effort of reaction F_2 coming from the plate 13. The efforts P_3, F_1 and F_2 are balanced in position of rest of the humerus H.

The component 1 is subjected to its weight cumulated with that of the humerus, weight of which P_H denotes the resultant. The component 1 is also subjected to the reaction of the button 32, i.e. to an effort F'_2 opposite the effort F_2. Finally, the component 1 is subjected to an effort F_3 exerted by the deltoid muscle supporting the humerus H.

The instantaneous centre C_1 of rotation of the surface S_1 with respect to the surface S'_1 is a centre common to the spheres defining the surfaces S_1 and S'_1. Taking into account the geometry of the component 3, this centre C_1 is

located in the glenoid cavity G, i.e. in a medial position with respect to the anatomical centre of rotation of the shoulder before operation.

In practice, the radius of curvature R_1 of the surfaces S_1 and S'_1 is chosen to be as great as possible, with the result that the centre C_1 is as medial as possible. The position of the button 32 in the dish 31 is also chosen to that end.

Furthermore, the instantaneous centre of rotation C_2 between the surfaces S'_2 and S_2 is the common centre of the spheres containing these surfaces and it lies beyond the surface S'_1 with respect to the surface S_2. In practice, the centre C_2 is substantially close to the anatomical centre of rotation of the shoulder before operation. The spatial relation between the centres C_1 and C_2 is therefore an image of the spatial relation between the centre C_1 and the anatomical centre of rotation with respect to which the muscles and the ligaments of the shoulder are implanted.

This positioning of the centres C_1 and C_2 makes it possible to facilitate the movement of abduction of the humerus H, without necessitating that the effort F_3 exerted by the deltoid muscle on that occasion be too great.

In effect, during a first step of abduction represented by the passage from the configuration of Figure 1 to that of Figure 2, the effort F_3 exerted by the deltoid muscle is exerted at a first, relatively large distance $\underline{d_1}$ from a straight line Δ_1 parallel to the effort F_3 and passing through the centre C_1. This distance d_1 represents the lever arm of the effort F_3 with respect to the instantaneous centre of rotation C_1, this relatively great lever arm making it possible to generate, relatively easily, a movement of slide of the plate 13 on the button 32, while the dish 31 remains immobile with respect to the component 2. During this first phase of abduction, the forces of reaction F_1 and F_2 between the glenoid cavity and the component 3 maintain approximately the same direction,

hence the dish 31 is maintained in equilibrium.

If the movement of abduction is prolonged until the configuration of Figure 3 is attained, the plate 13 continues to slide on the surface S'_1 of the intermediate component 3, while the dish 31 starts a movement of slide against the surface S_2 of the component 2. In effect, during this additional movement corresponding to the passage from the configuration of Figure 2 to that of Figure 3, the efforts F_1 and F_2 change direction.

If the movement of abduction is continued up to a maximum opening corresponding substantially to a horizontal position of the humerus, the stem 12 may come into abutment against the surface 331 of the washer 33 at the level of its upper part and the movement of articulation then occurs solely by a displacement of the dish 31 with respect to the component 2. In practice, the essential function of the washer 33 is to avoid a metal/metal contact between the plate 11 or the stem 12 and the dish 31.

In this way, the instantaneous centre of rotation of the articulation no longer lies in the glenoid cavity, like C_1, but inside the humerus, in a position closer to that of the anatomical centre of rotation. In this posture, the value of the lever arm $\underline{d}_2$ between the effort F_3 exerted by the deltoid muscle and the centre C_2 is of the same order of magnitude as the value of $\underline{d}_1$.

In practice, the centre C_1 describes, during the movement of abduction, an arc of circle A_1 virtually merged in the Figures with the trace of the surfaces S_2 and S'_2 as the radii R_1 and R_2 are such that the centre C_1 lies virtually at the level of these surfaces. This arc of circle A_1 is the locus of these instantaneous centres of rotation in the course of the movement of abduction. The centre C_2 describes an arc of circle A_2 which constitutes the locus of the centres of rotation between the surfaces S'_2 and S_2.

The locus A_1 of the centres of rotation C_1 is not necessarily merged with the trace of the surfaces S_2 and S'_2, this configuration following simply from the version shown in the Figures. In practice, the locus A_1 is as medial as possible and, for example, located in the component 2 or in the glenoid cavity G, in order to increase the lever arm of the deltoid muscle.

As is more particularly visible in Figure 5, the prosthesis according to the invention presents a considerable dynamic stability. In effect, if, from the position of Figure 2 and under identical load conditions, the dish 31 is displaced in the direction of arrow F_4, there is created, due to the offset of the efforts F_1 and F_2, a return couple C_4 which tends to return the component 3 in a direction opposite the displacement F_4, thus creating the conditions of a stable equilibrium of the component 3.

In the second form of embodiment of the invention shown in Figure 6, the components 1 and 2 are respectively intended to be anchored in the femur F and the hip bone I. They are similar to those described with reference to the first embodiment. The intermediate component 3 differs from the preceding one in that it has a substantially bi-convex shape with a first surface S'_2 in the form of portions of sphere of which C_1 denotes the geometrical centre and a second surface S'_2, likewise in the form of portions of sphere, of which C_2 denotes the geometrical centre. The centres C_1 and C_2 are the instantaneous centres of rotation during the movements of slide of the plate 13 of the component 1 with respect to the component 3 and of the component 3 with respect to the component 2.

In practice, forces of friction (not shown) must be overcome during the movements of the humerus H or of the femur F. These forces have low values with respect to the efforts mentioned above, which makes it possible to

disregard the forces of friction in the foregoing explanations.

In addition to the facility of the movement of abduction that it allows, the prosthesis according to the invention presents the particular advantage that the interventions to be made on the glenoid cavity or on the hip bone for the implantation of the component 2 are limited, and even nil. In effect, the prosthesis according to the invention does not necessarily comprise a glenoid or cotyloid component since the glenoid or cotyloid articular surface may be conserved if its state is good. In the case of a complete prosthesis as shown in the accompanying Figures, the component 2 has a small volume, unlike the corresponding components of the majority of prior art prostheses.

In the third form of embodiment of the invention shown in Figures 7 to 9, the components 1 and 2 are respectively intended to be anchored in the humerus and in the glenoid cavity. The intermediate component 3 defines two convex articular surfaces S'_1 and S'_2 intended to cooperate respectively with concave articular surfaces S_1 and S_2 formed by the components 1 and 2.

The loci of the instantaneous centres of rotation of the surfaces S'_1 and S'_2 on the surfaces S_1 and S_2 are, as previously, located on either side of the surface S'_1.

This embodiment differs from the preceding ones in that the humeral component 1 is not in one piece but in two parts. More precisely, it comprises a humeral stem 15 and a finger 16 of which one end 16a forms the plate 13, while its other end is of substantially spherical shape and received in a cavity of corresponding shape in the stem 15.

The plate 13 is substantially oval in shape, with its smallest dimension in the plane of Figure 7, which makes it possible to improve the amplitude of the movement of abduction.

As is visible in Figure 8, the amplitude of the movement transverse to the sagittal plane is limited.

The width of the plate 13 in the plane of Figure 8 avoids an untimely separation of the elements 1 and 3.

It will be noted that one sole one-piece element 36 performs the role of the button 32 and of the washer 33 of the first embodiment.

In the fourth form of embodiment of the invention shown in Figures 10 and 11, the components 1 and 2 are respectively intended to be anchored in the femur and in the hip bone. The intermediate component 3 is similar to that of the third embodiment and the convex surfaces S'_1 and S'_2 that it defines induce the same positioning of their instantaneous centres of rotation as previously.

This embodiment differs from the preceding one in that the assembly between the femoral stem 15 and the finger 16 is conical. A truncated part 17 is provided on the finger 16 in order to be engaged in a housing in the stem 15.

In addition, the plate 13 which defines the concave surface S_1 intended to cooperate with the surface S'_1 of the component 3 is of substantially rectangular shape. As in the third embodiment, the smallest dimension of the plate 13 is disposed in the plane of Figure 10.

It will be noted that the finger 16 is not rectilinear, which makes it possible to optimalize the position of the centre of rotation of the plate 13. In practice, the angle α between the axis transverse to the surface S_1 and the longitudinal axis of the stem 15 is chosen to be equal to about 130°, which presents a good compromise between the necessity of obtaining a maximum amplitude of the movement of abduction and the wish to reduce the risk of dislocation.

According to an aspect of the invention which has not been shown, the

neck joining parts 13 and 17 of the finger 16 may equally well be bent, in the sagittal plane, in a direction opposite that shown. This neck may also be bent in a plane perpendicular to the sagittal plane, which makes it possible to vary the anteversion.

Assembling between the elements 15 and 16 may be reversible. In other words, the finger 16 may possibly be dismounted from the stem 15. This reversible nature of the assembling of the elements 15 and 16 may also be envisaged for the third embodiment.

The invention has been represented with articular surfaces in the form of portions of spheres. However, it is applicable to other types of surfaces, for example cylindrical with circular or paraboloidal base, in which case the position of the instantaneous centres of rotation may vary during the movement of abduction on loci which are not necessarily arcs of circle. In the same way, it may be conceived that the surfaces S_1 and S'_1 be cylindrical, with rectilinear generatrix and with circular base, with a substantially antero-posterior axis allowing only the movement of abduction, while the surfaces S_2 and S'_2 would remain spherical, allowing both the movement of abduction and the axial-humeral or axial-femoral rotation.

In the accompanying Figures, the lengths of the arrows are indicative and must not be considered as strictly representative of the intensities of the corresponding efforts. The same applies to their orientation.

The invention has been represented during its use with complete shoulder and hip prostheses. However, it is applicable with a prosthesis not having a glenoid component, the concave articular surface of the glenoid cavity being used instead of the surface S_2 shown in the Figures. The same applies to a hip prosthesis where the natural cotyloid cavity can be used. The characteristics of

the different forms of embodiment shown may be combined together within the framework of the present invention. In particular, the prostheses of the second and fourth embodiments might be adapted to the shoulder, while those of the first and third embodiments might be adapted to the hip.